Advanced Material Technologies for Lightweight, Chemical/Biological Protective Clothing

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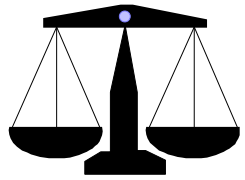
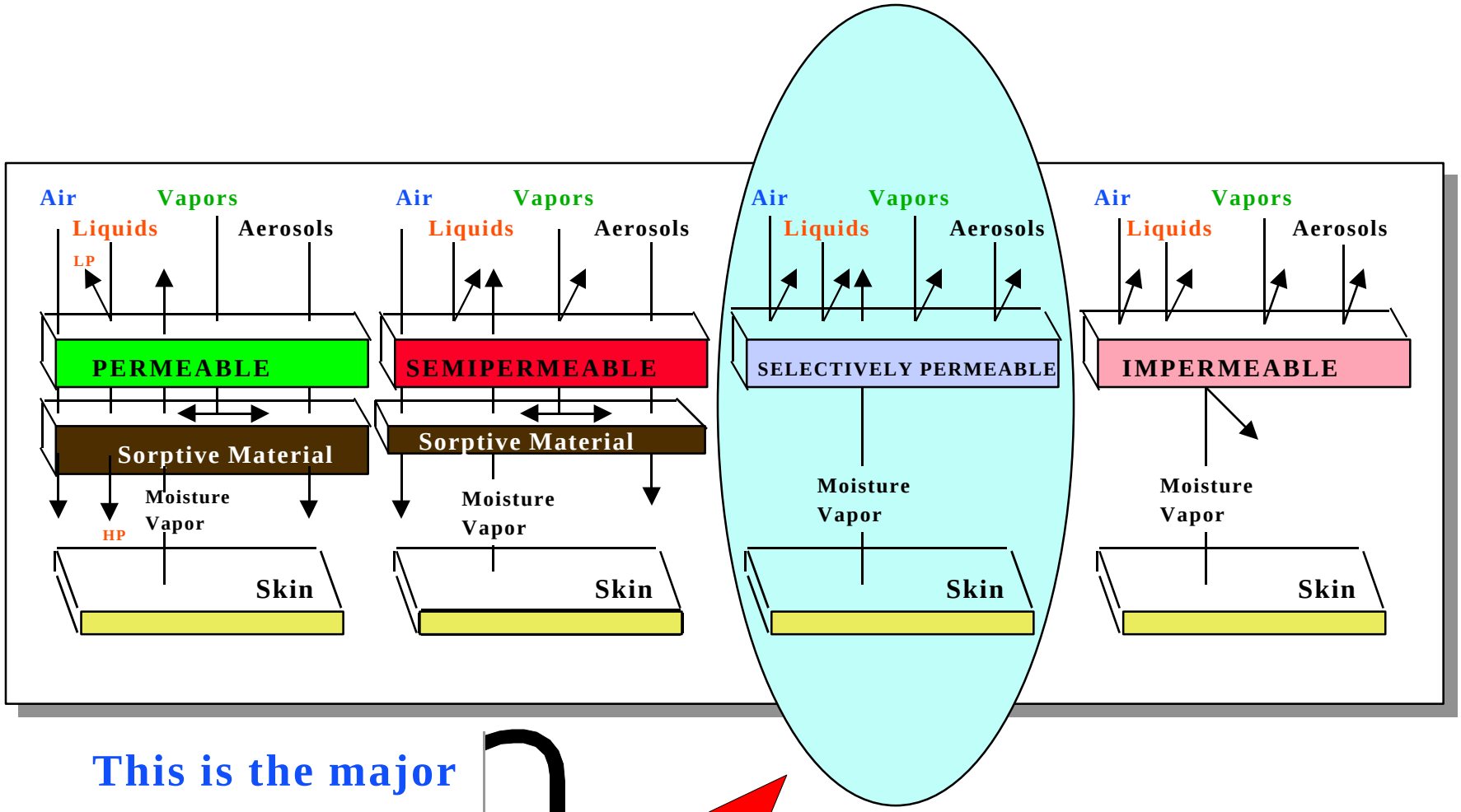
Objectives



- **Develop advanced, lightweight materials for CB protective clothing:**
  - **Based on selectively permeable membrane technologies**
  - **Protect against chemicals, toxins, and microorganisms**
  - **Waterproof and moisture vapor permeable**
  - **Desirable physical properties**
  - **Low-cost and launderable**
- **Develop a lightweight CB protective duty uniform**

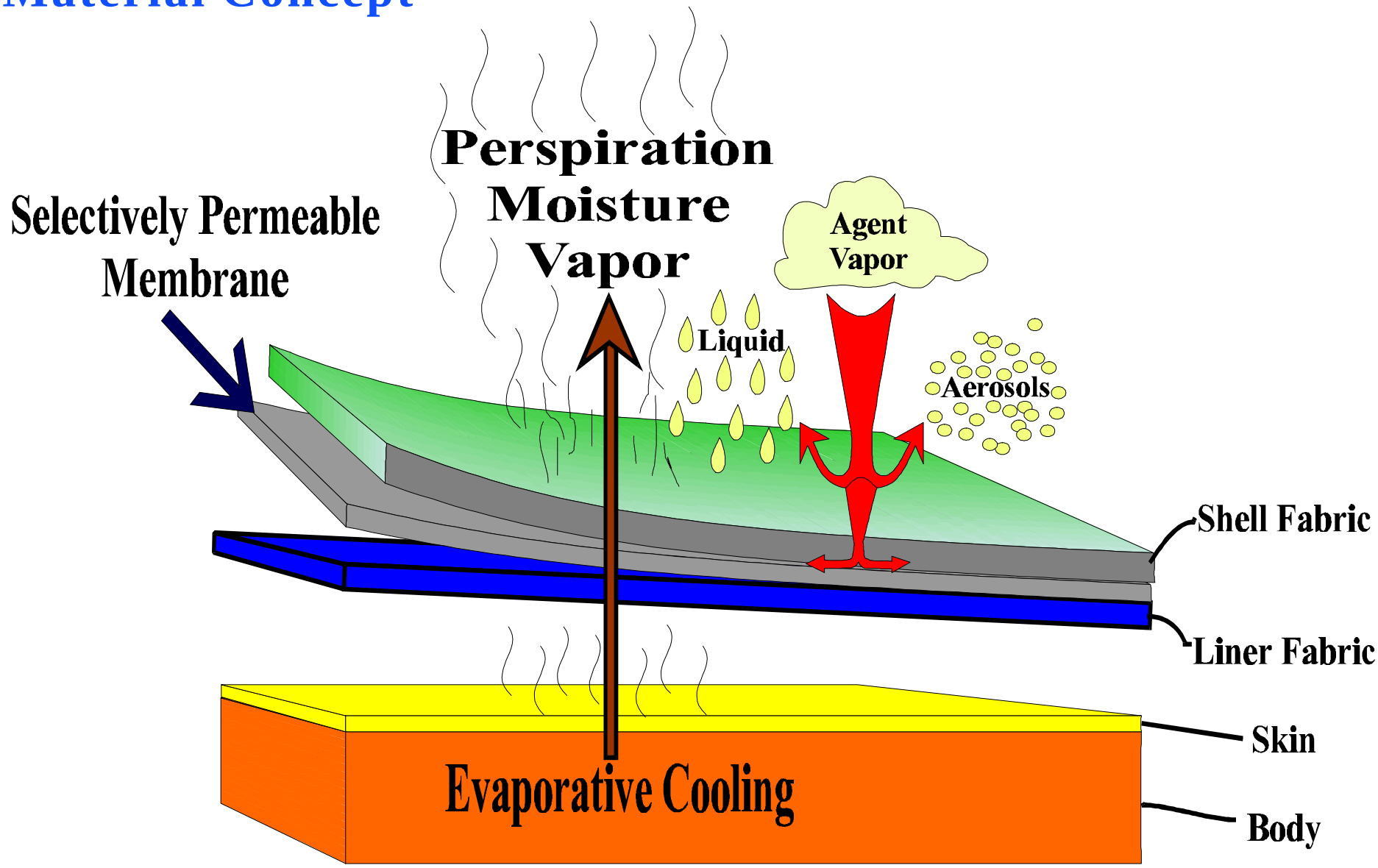
Types of Materials



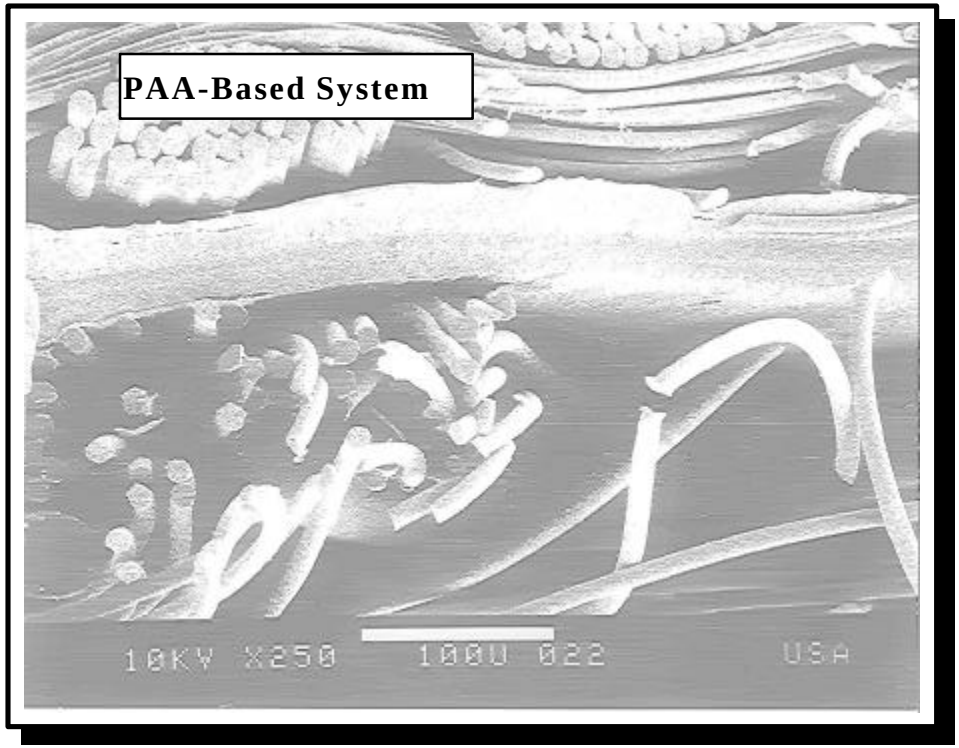
This is the major thrust of our program.

LP: Low Hydrostatic Pressure
HP: High Hydrostatic Pressure

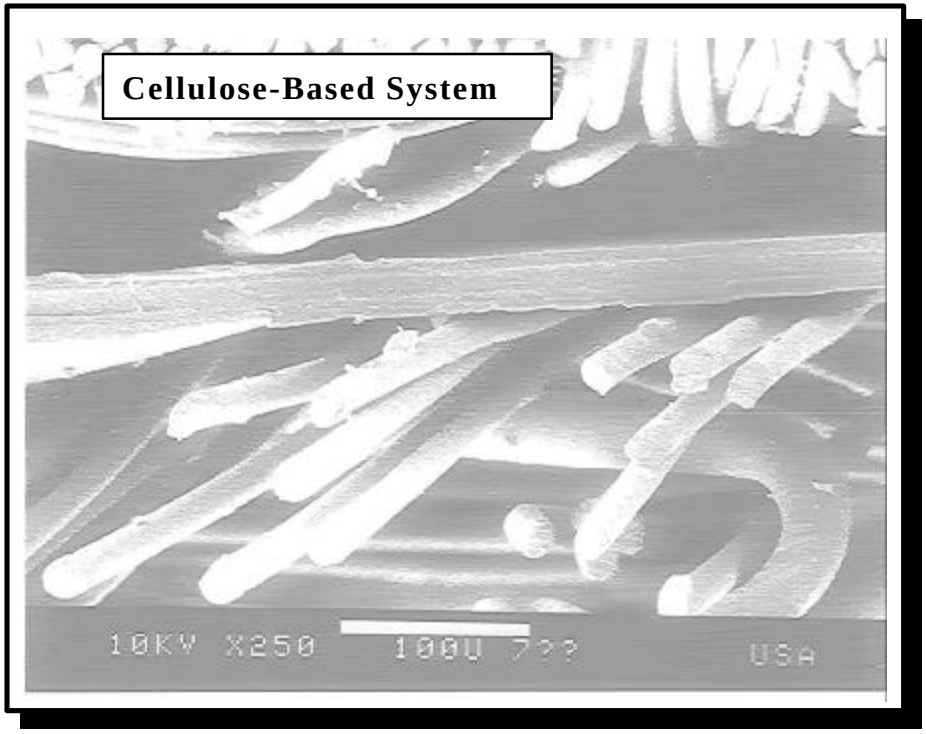
Material Concept



Membrane Structures



Polyallylamine-Based Membrane/Fabric System
Cross Sectional View (250x)



Cellulose-Based Membrane/Fabric System
Cross Sectional View (250x)

Performance Goals

Chemical Protection: Blister (HD), Nerve (GD, VX) Agents
Biological Protection: Microorganisms (10 to 0.001 μm)

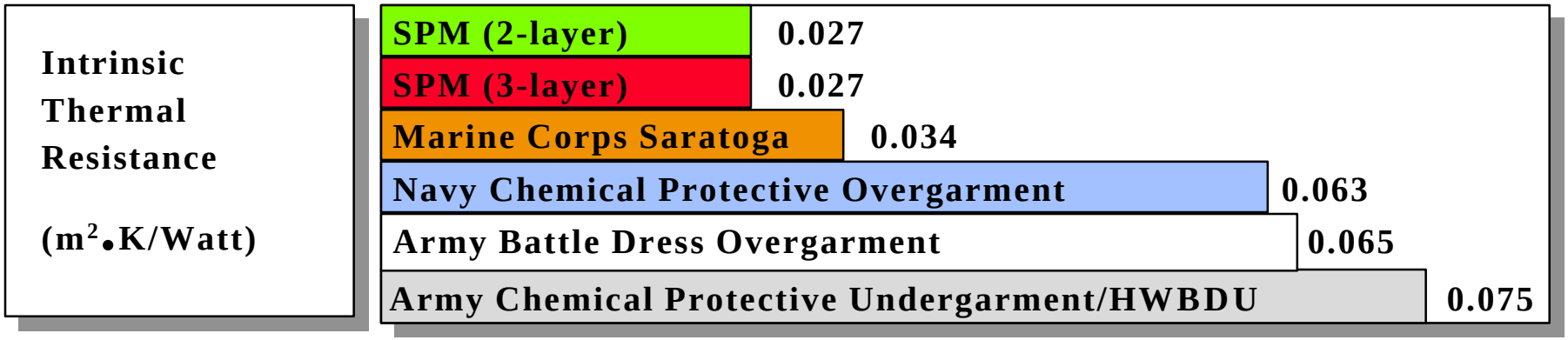
Water Vapor Flux @ 32°C ≥ 1800 $g.m^{-2}/24$ h*
Hydrostatic Resistance ≥ 35 lb/in^2

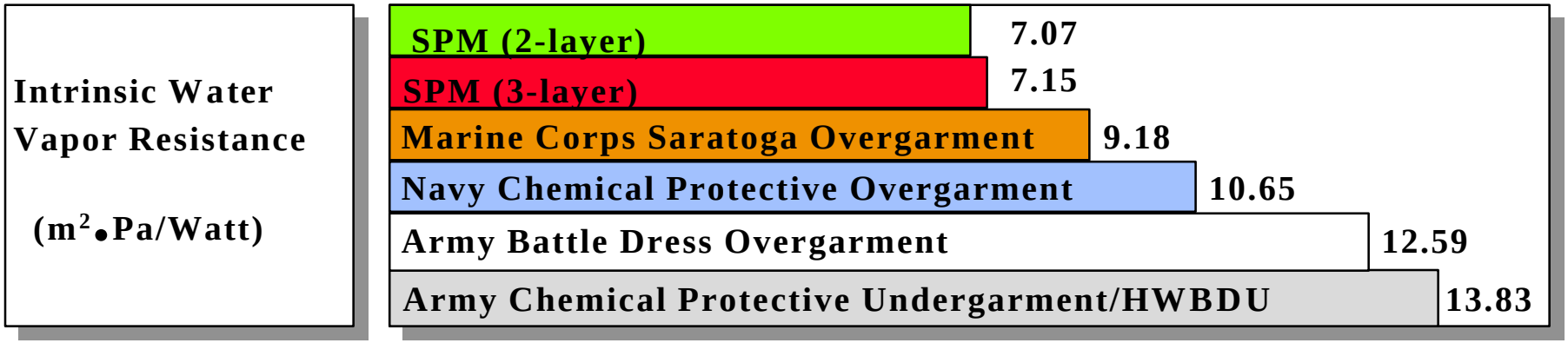
Bonding Strength ≥ 10 lb/in^2 **Stiffness ≤ 0.01 lb**
Weight ≤ 7 oz/yd^2 **Thickness ≤ 18 mils**

Torsional Flexibility: Pass
Water Permeability after flexing at 70 °F and -25 °F: Pass

*Dynamic Moisture Vapor Permeation Cell

Evaporative Cooling Potentials
(Guarded Hot Plate)

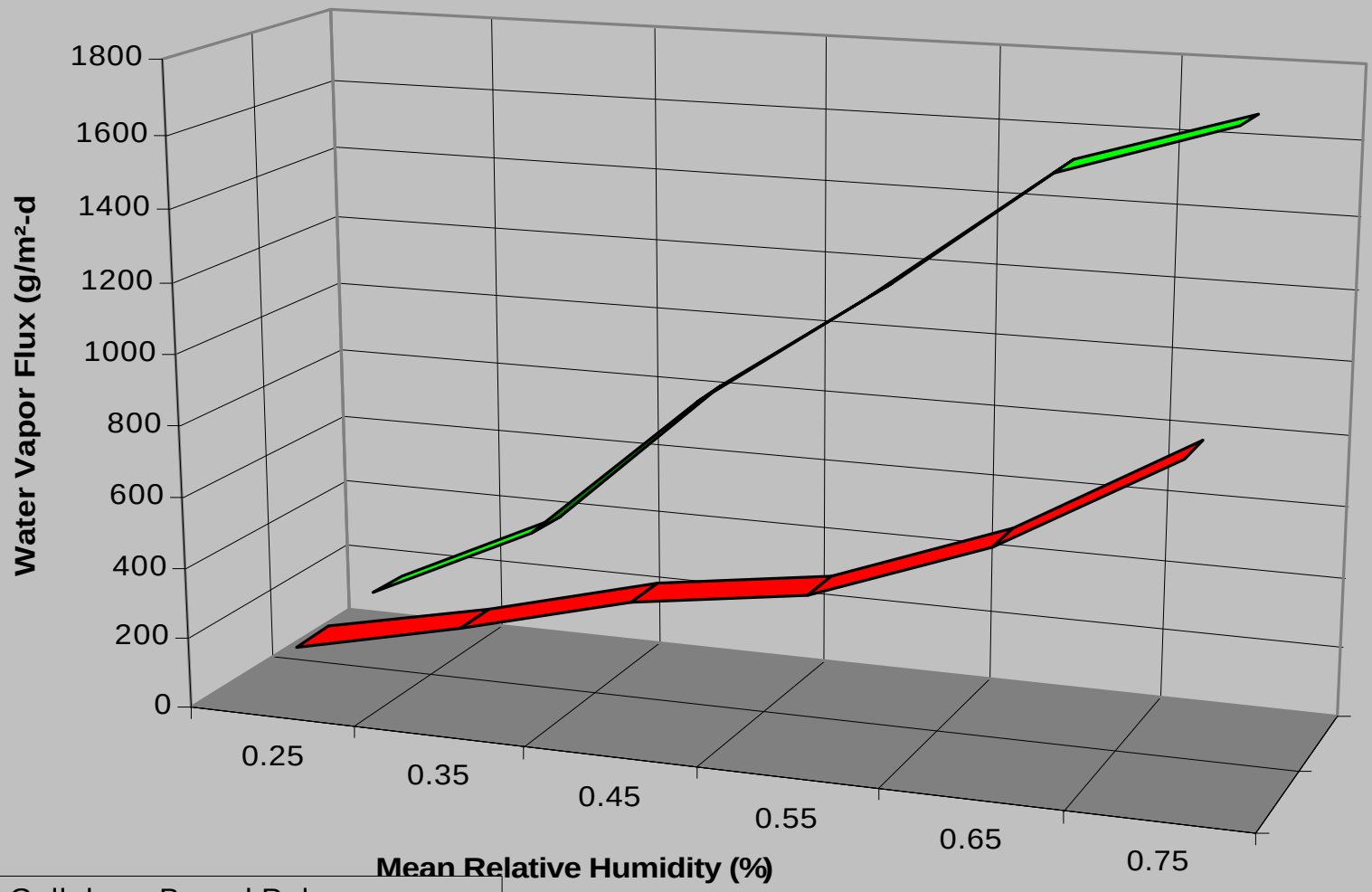




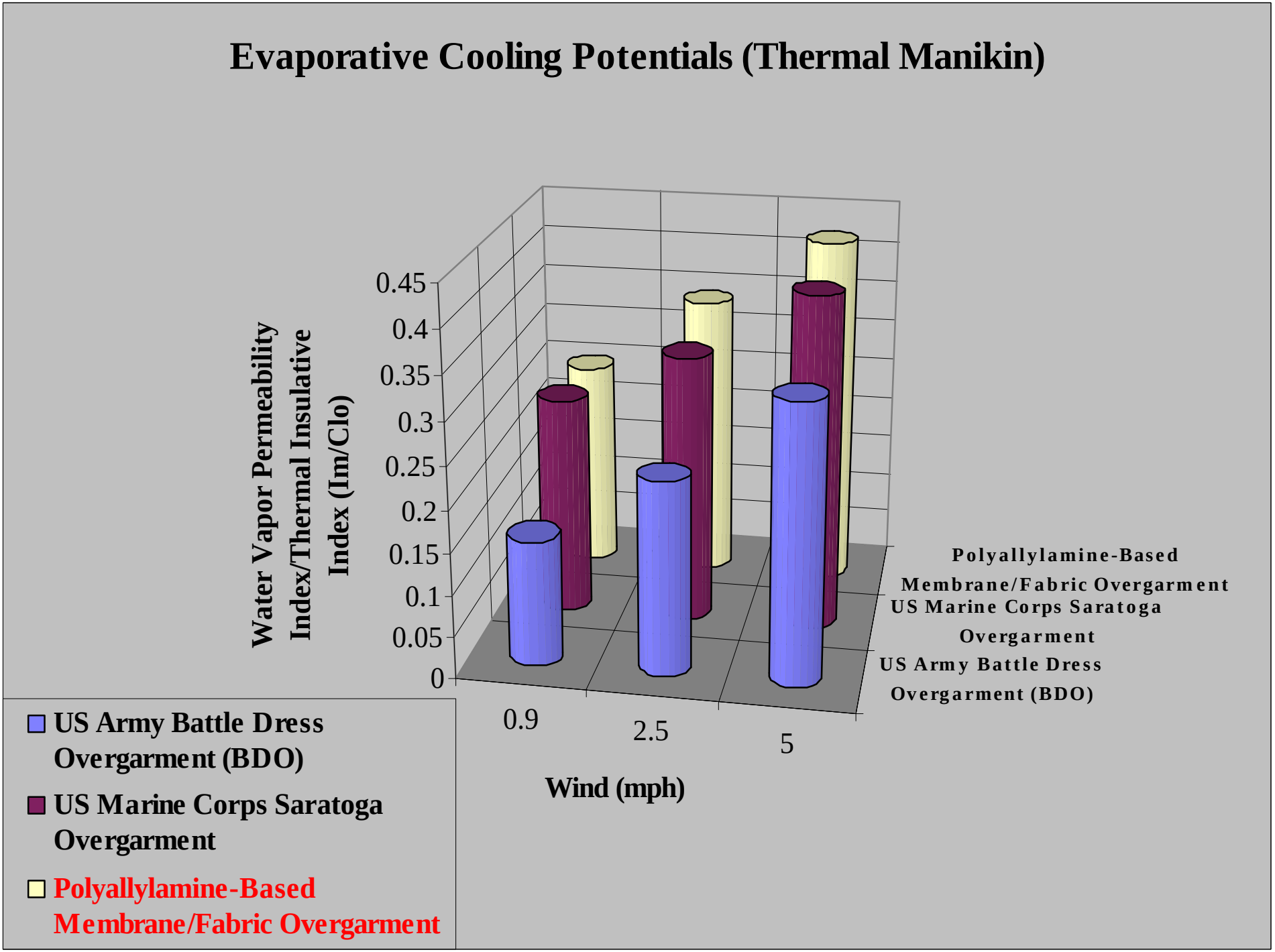
SPM (2-layer): Polyallylamine-Based Membrane Laminated to Shell Fabric
SPM (3-layer): Polyallylamine-Based Membrane Laminated to Liner & Shell Fabric
HWBDU: Hot Weather Battle Dress Uniform

Moisture Vapor Transmission Rate

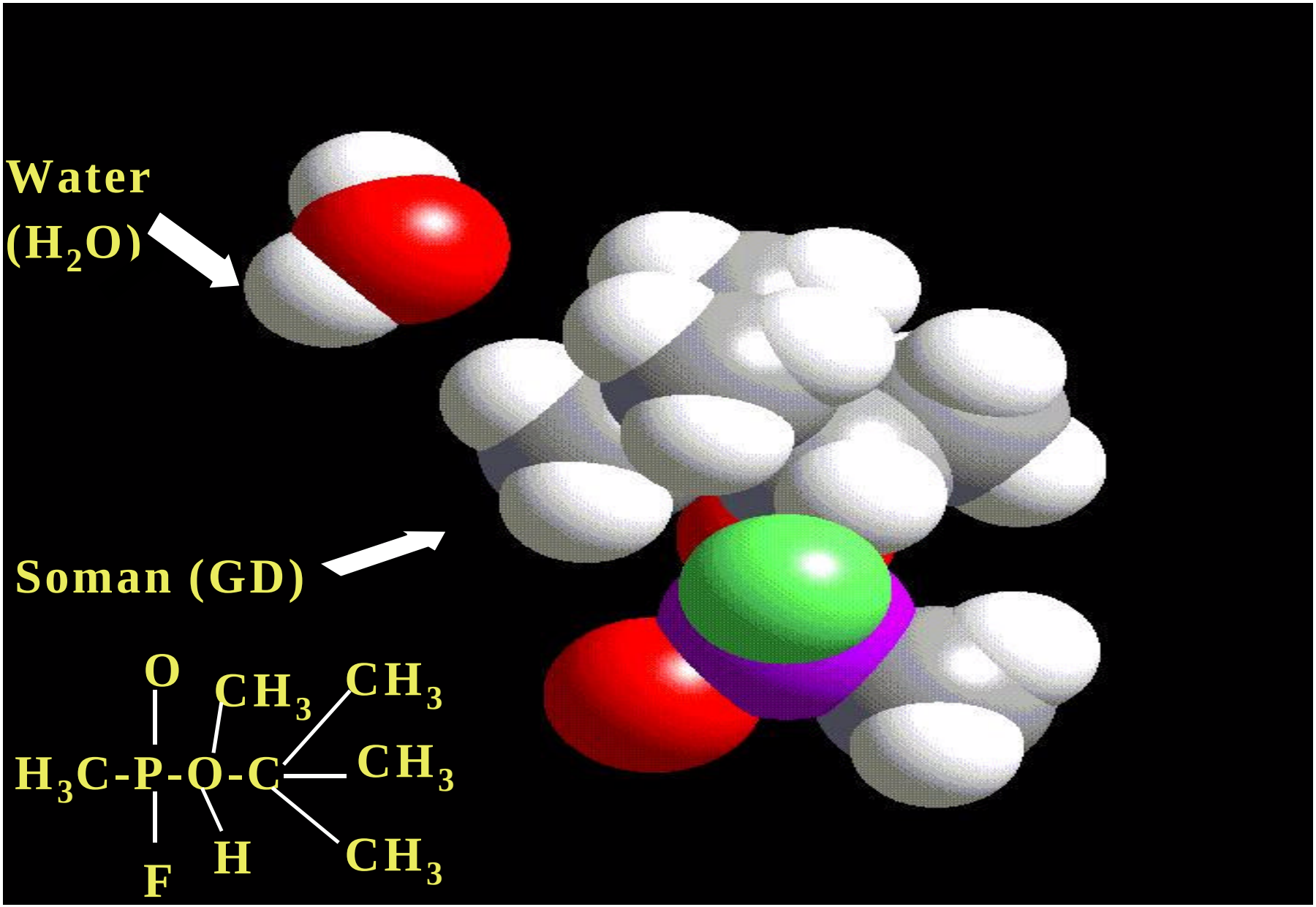
(Dynamic Moisture Vapor Permeation Cell)



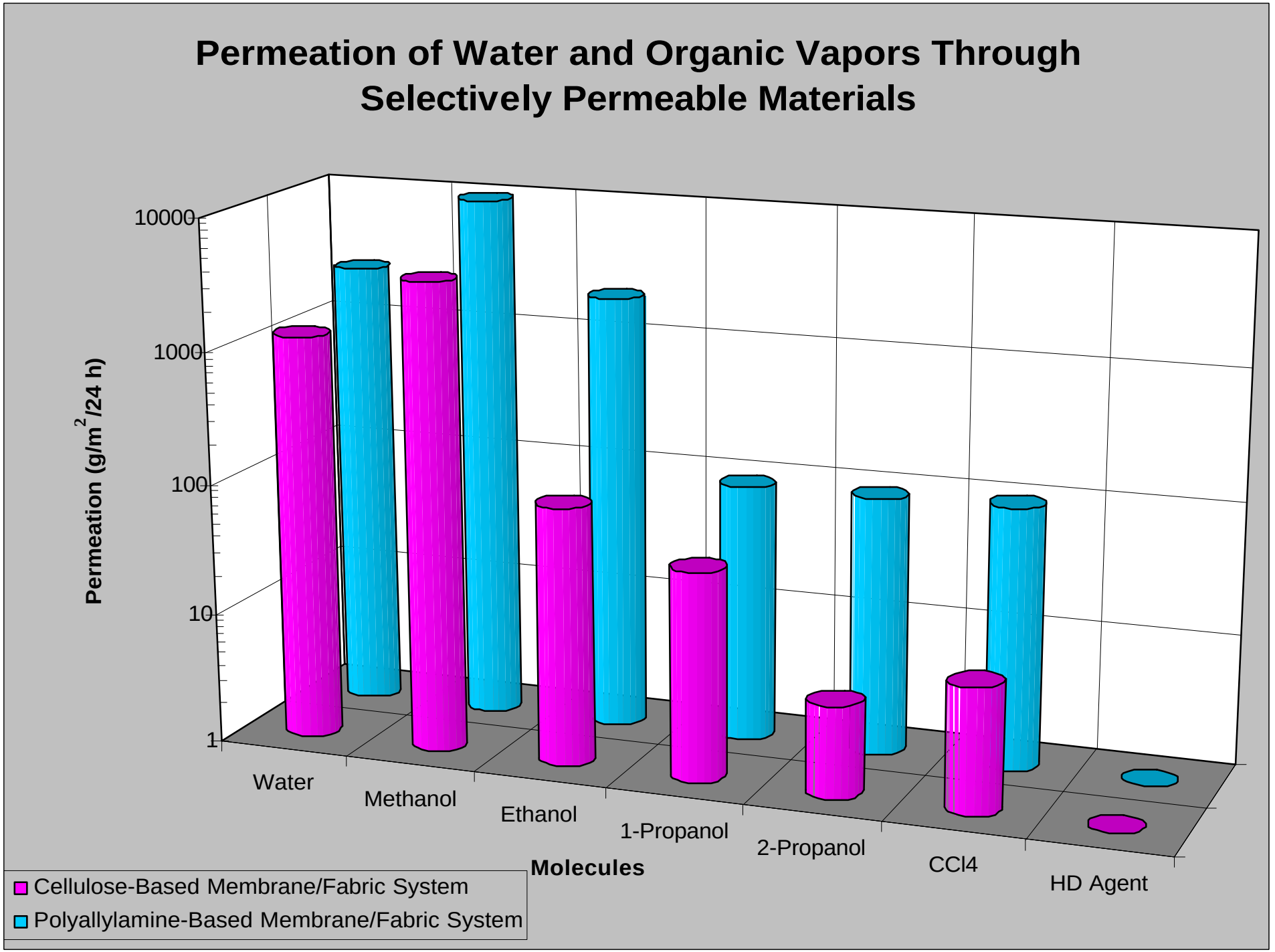
Evaporative Cooling Potentials (Thermal Manikin)



Relative Size of Water and Soman Molecules

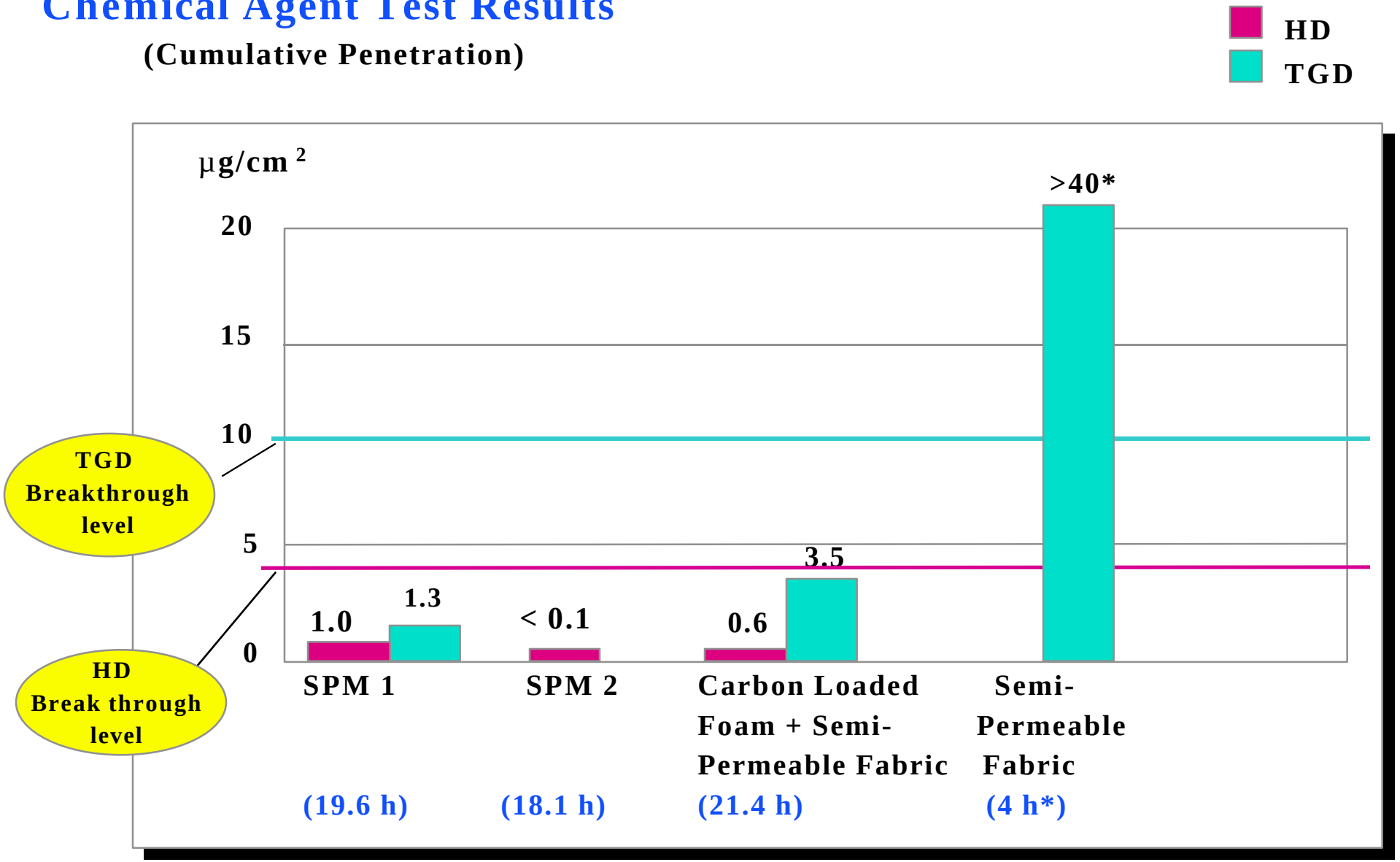


Permeation of Water and Organic Vapors Through Selectively Permeable Materials



Chemical Agent Test Results

(Cumulative Penetration)



Data were generated without the use of PE film.

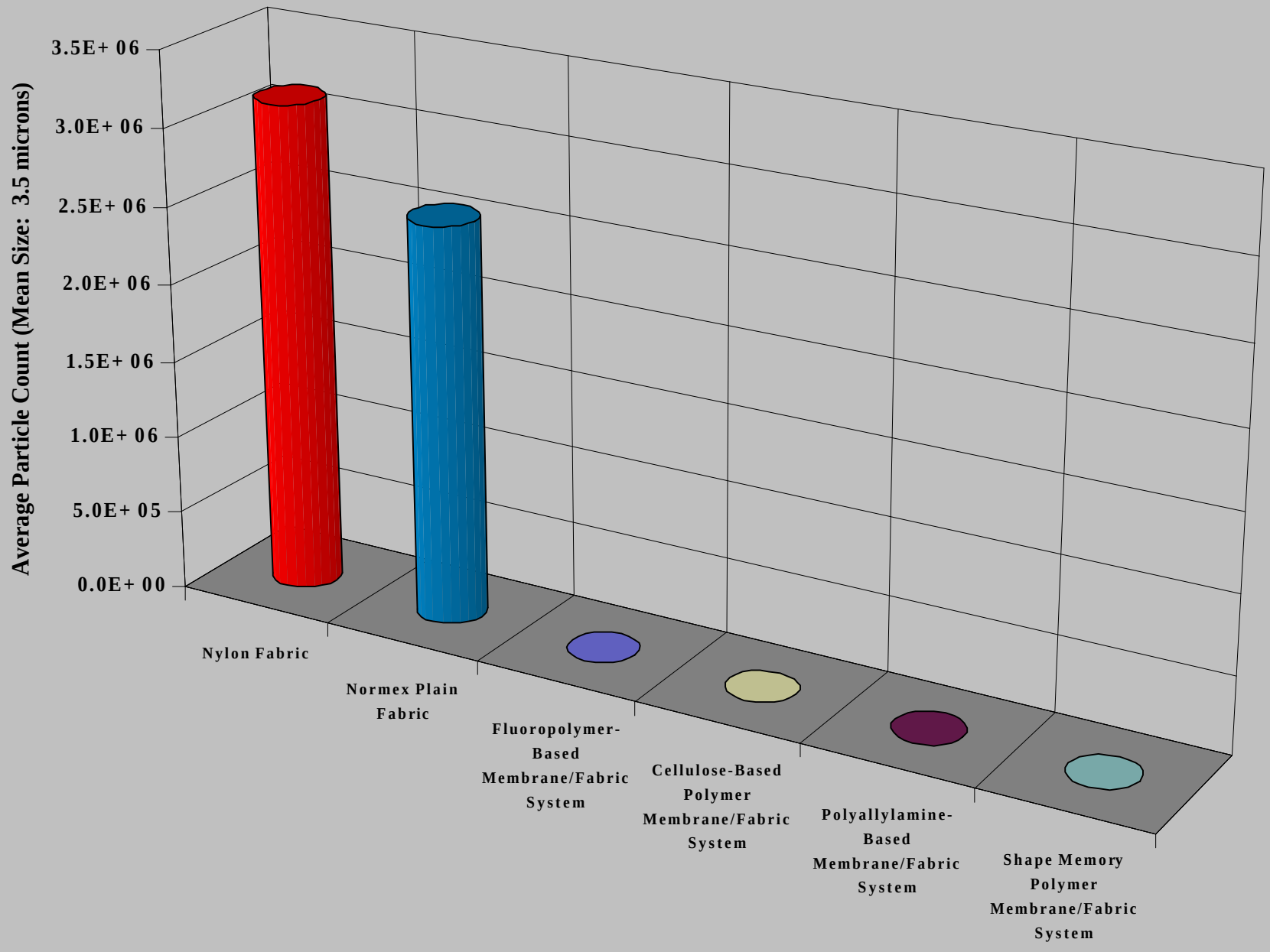
SPM: Selectively Permeable Membrane/Fabric System

SPM 1: Polyallylamine-Based

SPM 2: Cellulose-Based

***Test were terminated due to heavy penetration**

Aerosol Penetration Through Various Fabrics



Durability/Comfort Limited Field Test

Obstacle Course, 1-week, Baseline: BDO*

- **Soldiers perceived the SPM1 prototype uniforms as being lighter, less bulky, cooler, and more comfortable to wear than the standard Battle Dress overgarment.**
- **Soldiers perceived the prototype uniform as being more noisy and less durable than the BDO.**

Obstacle Course and Wirsing Cross Country Course. 2-weeks, Baseline: Saratoga*

- **General soldier acceptance for the SPM1 prototype uniforms was excellent. 12 out of 13 test subjects favored the improved SPM1.**
- **Soldiers rated the SPM1 as more durable, of better weight, and of better overall material than the base line Saratoga.**
- **The improved SPM was more durable than the baseline Saratoga.**
- **Soldiers rated the SPM more noisy than the Saratoga.**

Weight

Weight (oz/yd^2)	7.3	5.8	14.8	13.3
	SPM 1	SPM 2	Battle Dress Overgarment (BDO)	SARATOGA

SPM: Selectively Permeable Fabric
SPM 1: Polyallylamine-Based Membrane/Fabric System
SPM 2: Cellulose-Based Membrane/Fabric System

BDO and Saratoga: US Military Fabric Systems.

Summary

Lightweight, non-carbon CB perm-selective protective fabric systems have been developed. ☑

Excellent dual use in CB/environmental protective clothing:

- **emergency responders**
- **pesticide applicators**
- **industrial chemical handlers**
- **medical personnel**
- **environmental clean-up workers.** ☑

Acknowledgements

Test Fabrics were developed/provided by W.L. Gore & Associates, Inc. and Akzo Nobel Central Research.

Durability/Comfort Field Relevance Tests were performed by the Human Research and Engineering Directorate, US Army Research Laboratory.

Live Agent Tests were Performed by the Design Evaluation Directorate, Edgewood RD&E Center, US Army Chemical/Biological Command and VERIDIAN, Calspan Operations.

Thermal Manikin Tests were Performed by the Bio-Physics Division, US Army Research Institute of Environmental Medicine.